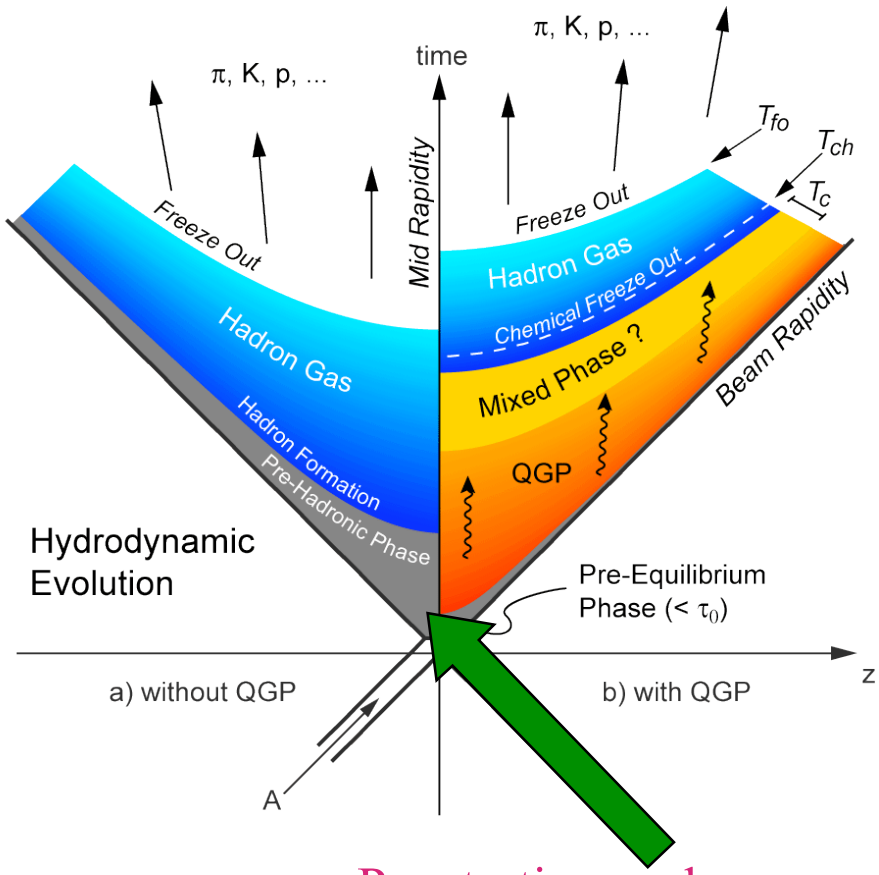
# Quark Matter 2008 summary
# February 4-10 in Jaipur, India
# (selected topics…)

Vi Nham Tram

NSD meeting

- A dense matter is observed when colliding heavy ions
- Discussion about the properties of the medium

# Heavy ions collisions




Penetrating probes needs to be created here

## Outline

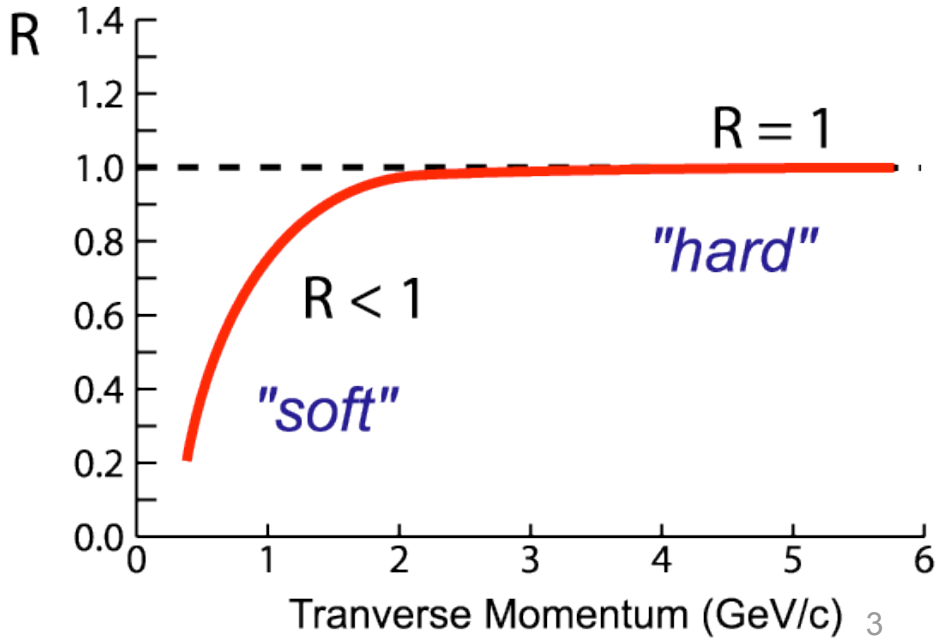
- Hard probes (early stage in the collision)
  - Jets
  - heavy quarks
- Leptons and dileptons
  - Do not interact strongly
  - Thermal radiation : T

# Nuclear Modification Factor

- It measures the deviation of the nucleus-nucleus collision from a superposition of pp collision ($N_{coll}$ )
  - For particles from hard processes, $N_{coll}$ scaling expected
  - For particles from soft processes (bulk), $N_{part}$ scaling expected
- Centrality used to define impact parameter (b) of the collision
  - Small b => central collision
  - Large b => peripheral collision

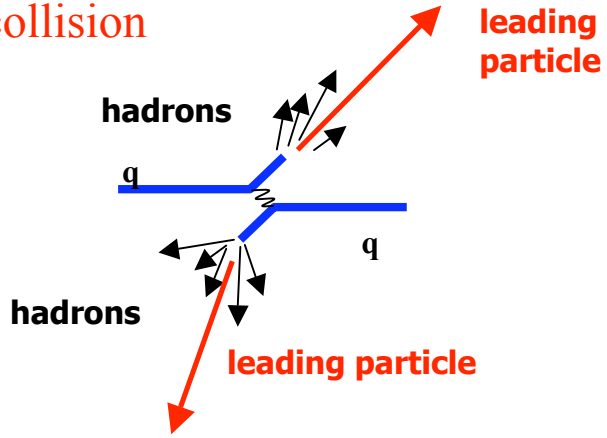
$$R_{AB} = \frac{1}{N_{Coll}} \frac{d^2N^{AB}/dp_T d\eta}{d^2\sigma^{pp}/dp_T d\eta}$$

$R_{AB} = 1$ → no nuclear effects (hard probes)

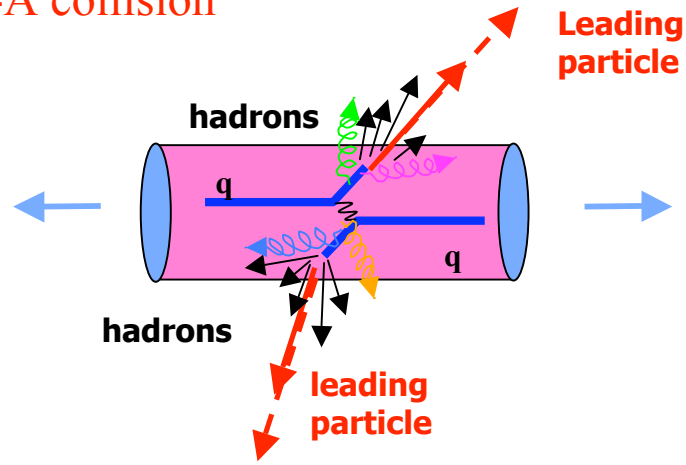


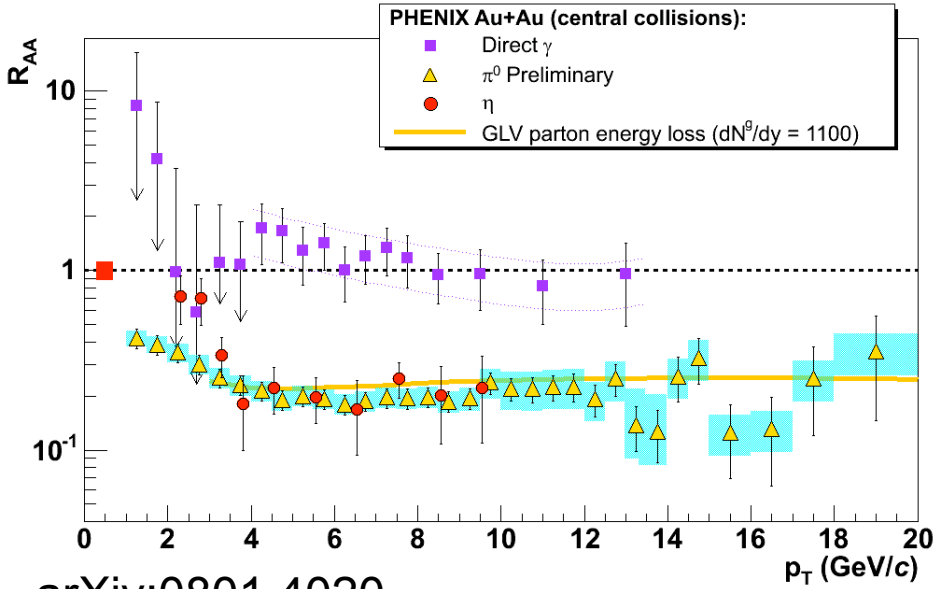
# How do we study it ? Single hadron

N-N collision




A-A collision

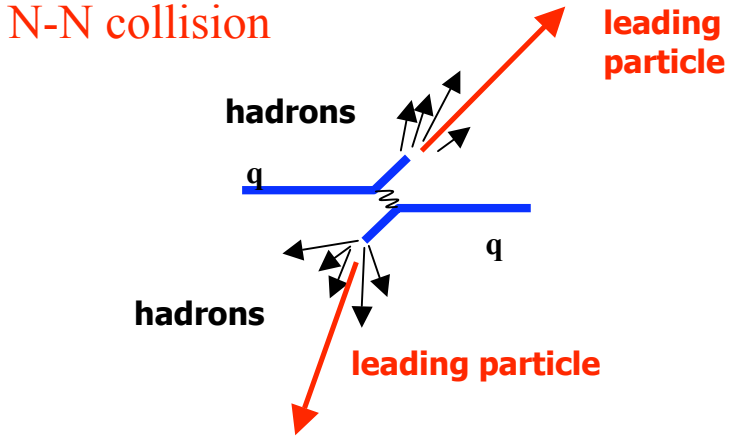


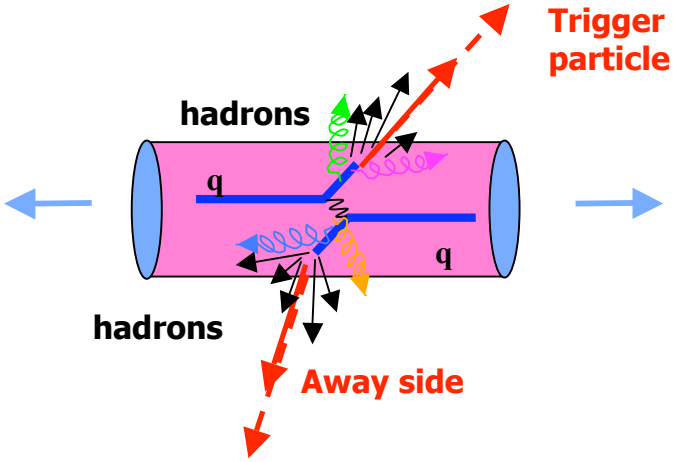



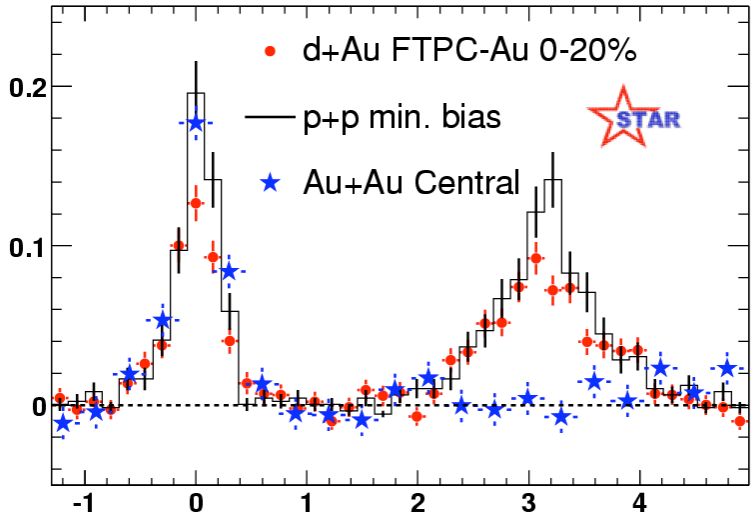

arXiv:0801.4020

$$R_{AB} = \frac{1}{N_{Coll}} \frac{d^2N^{AB}/dp_T d\eta}{d^2\sigma^{pp}/dp_T d\eta}$$

# How do we study it ? Di-hadron correlation




PRL 91 (2003) 072304

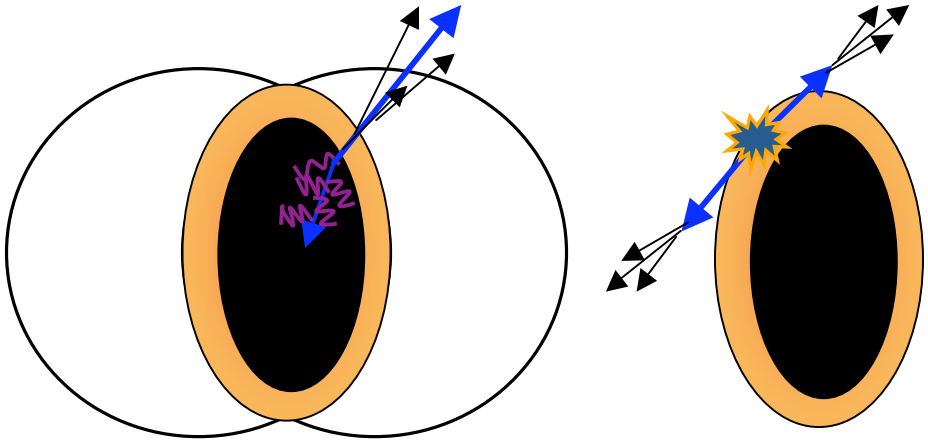
Both results : significant suppression

The hard jet loses a significant amount of its energy via radiating gluon induced by multiple scattering

Can we characterize the medium ?
Quantify its density ?


5

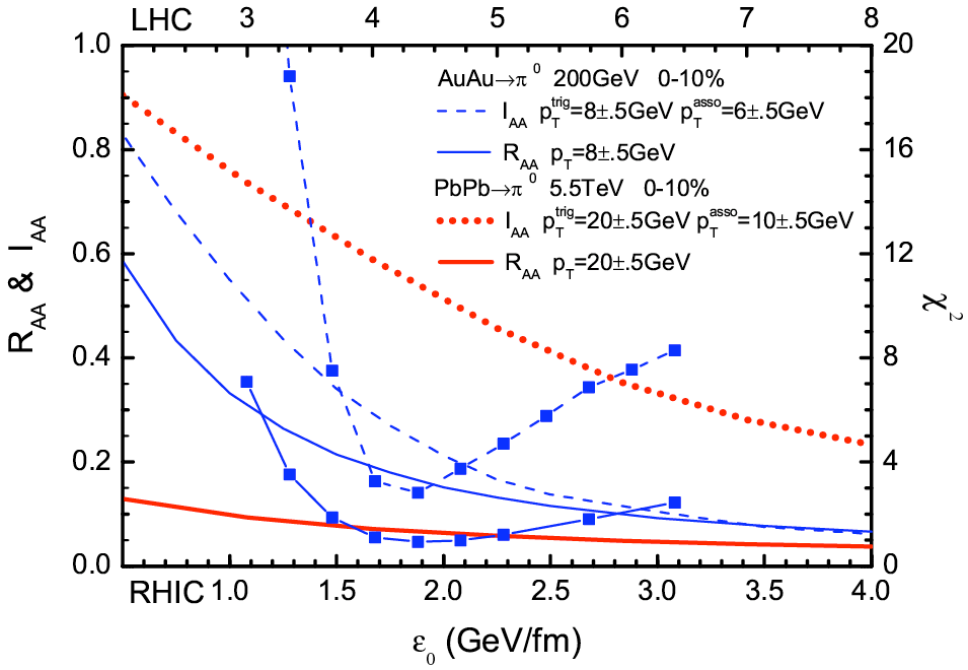
# How sensitive to Energy loss ?



Single hadron emitted from the surface

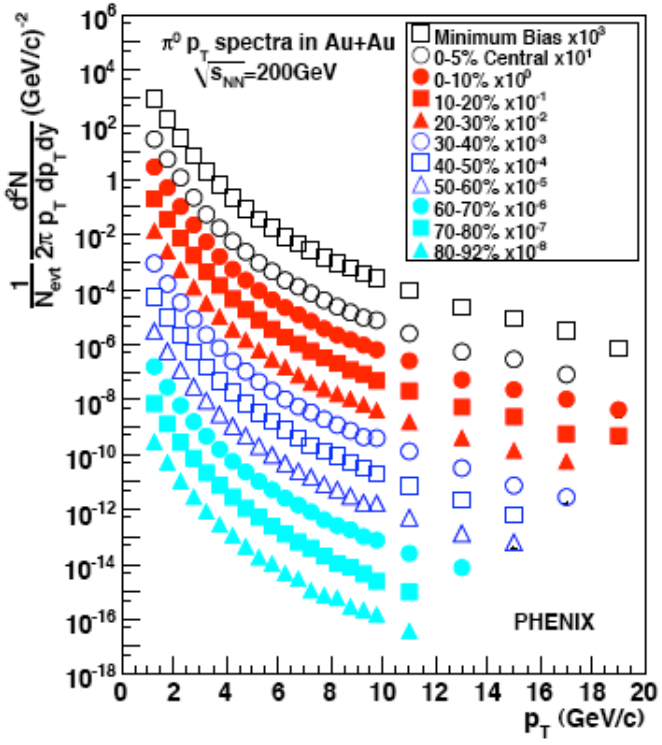
Energy loss parameter :
$\varepsilon_0$ α initial density
(in most central collisions)

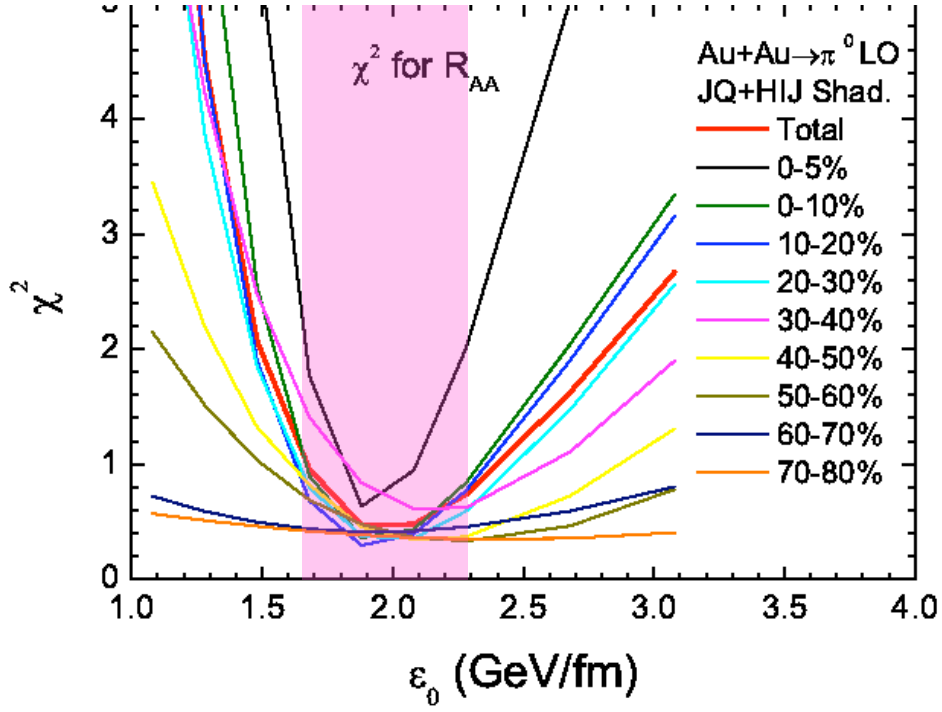
Di-hadron correlations more sensitive to probe of initial density




H. Zhong, XN Wang et al., PRL 97 (2006) 25

# Fit to all single hadron Raa factors in Au+Au with different impact parameters at RHIC energy




Better precision of measurements
=> Qualitative to quantitative

ArXiv 0801.4020 and H. Zhong QM08

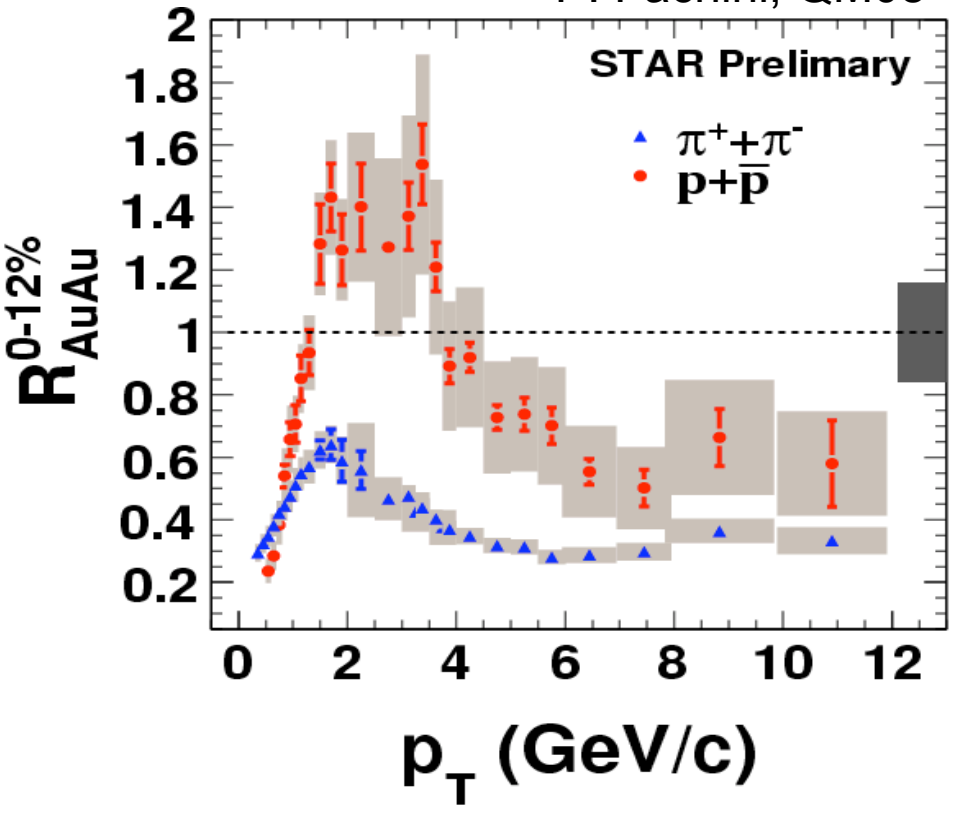
# Is there a difference in $E_{loss}$ of q and g ?

- Energy loss for gluon radiation is higher for gluon than for quark : color factor effect

$$\frac{\Delta E_g}{\Delta E_q} \sim 9/4$$

- Proton jet dominantly from gluon and pions jet from quarks
- Higher suppression of gluons lead to higher suppression of proton

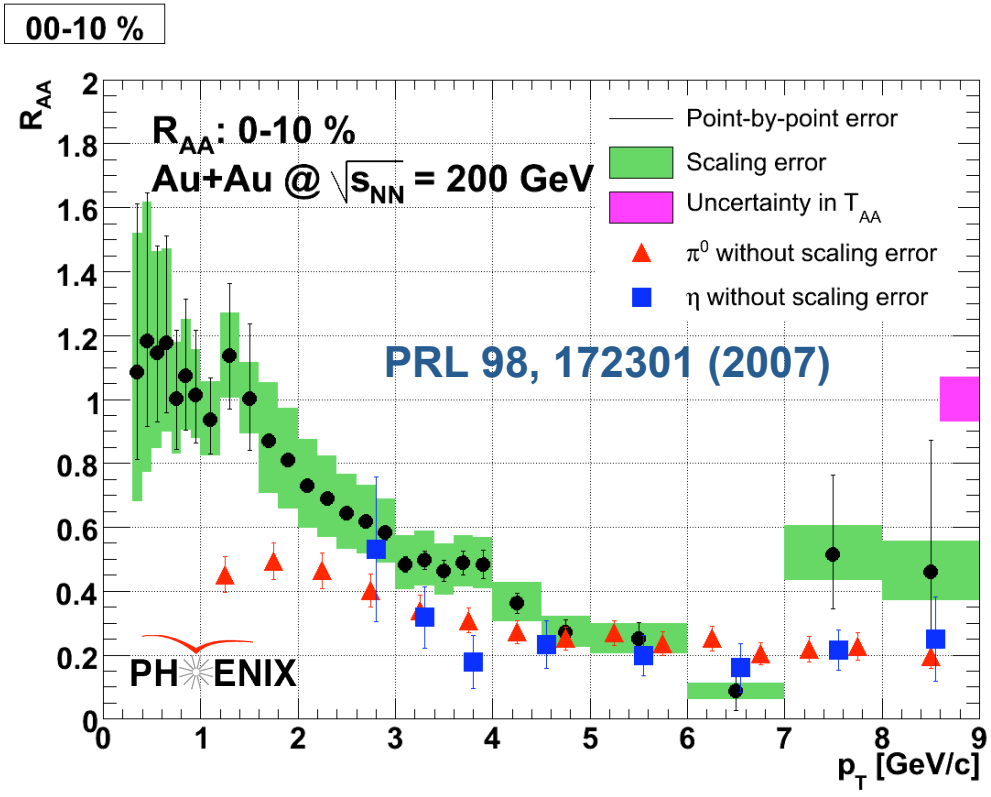
P. Fachini, QM08




Naïve factor 9/4 Color effects not observed up to $p_T$ ~ 12 GeV/c

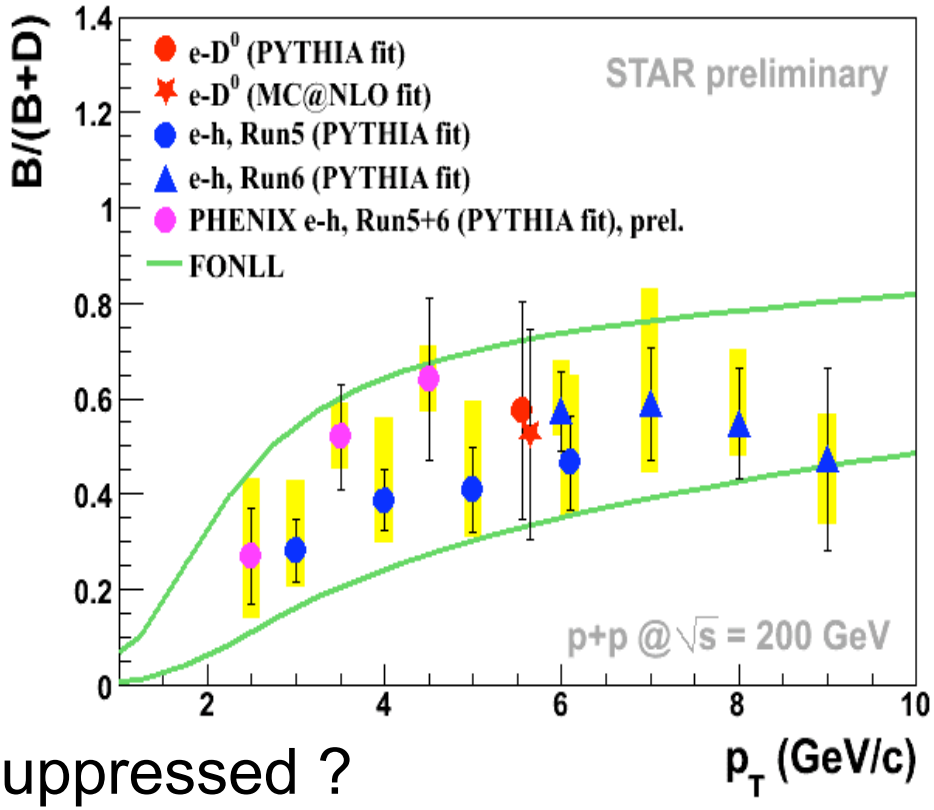
# Heavy quark energy loss, unsolved puzzle

- Mass hierarchy :
  - $\Delta E_q(m=0) > \Delta E_q(m>0)$
- Measurement at high $p_T$ via semi-leptonic decay
- high $p_T$ non-photonic $e^{\pm}$ suppression, increasing with centrality




What fraction of this is bottom?

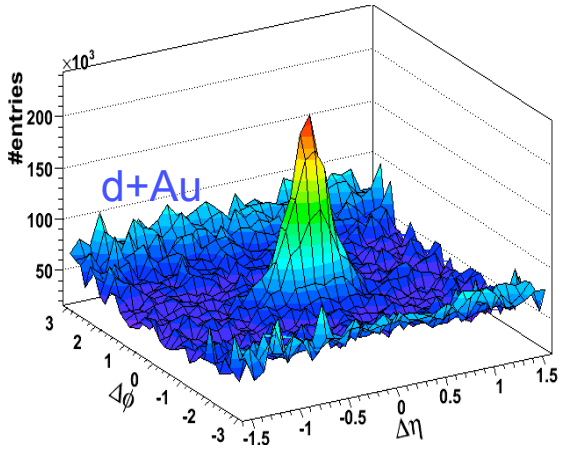
# Bottom fraction



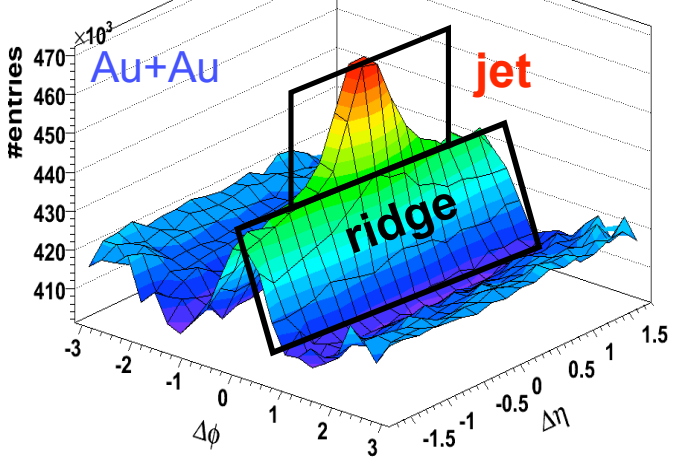

Morino QM06
Mischke QM06

High pt B suppressed ?
HOWEVER model base on simulation : model dependent
Next step : Need to measure it with displaced vertices
with upgrade vertex detectors (STAR and PHENIX)

# Ridge in Heavy Ion Collisions



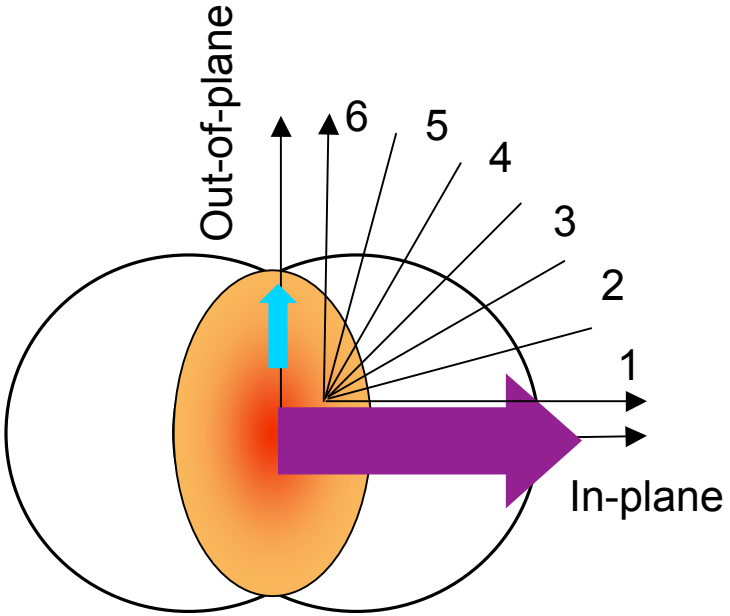

J. Putschke, QM2006

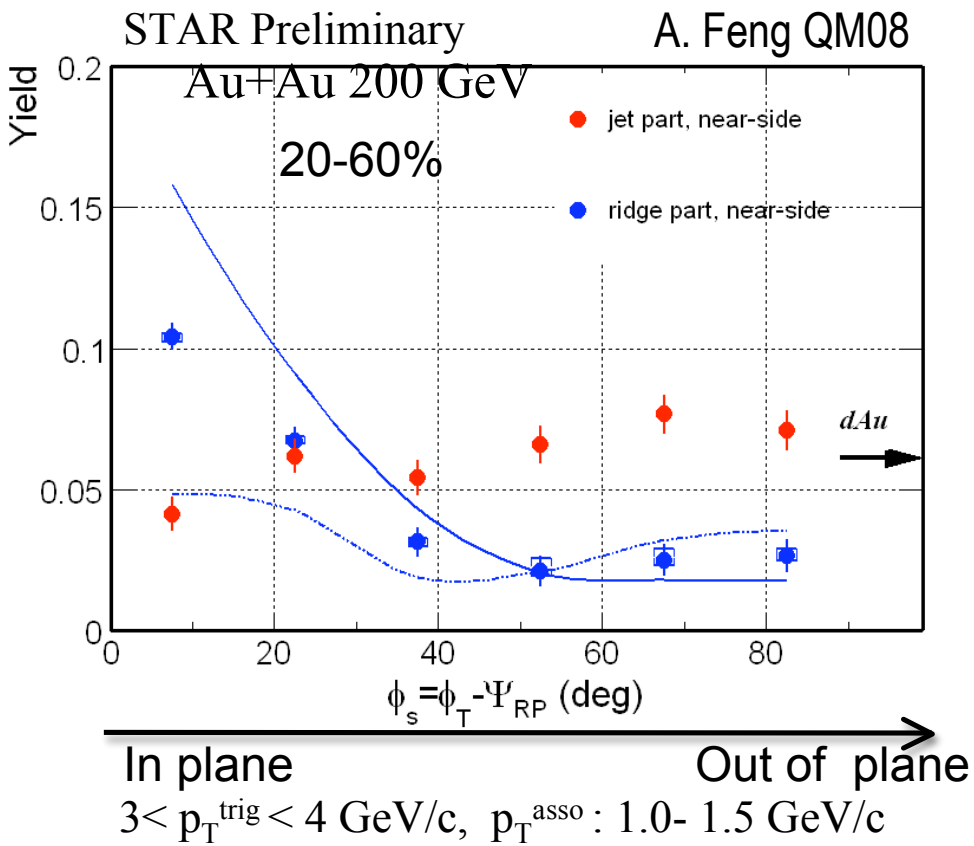



- What is the Ridge ?
  - medium response induced by the jet ?
  - Jet modification in the medium ?

Long range $\Delta\eta$ correlations in A+A collisions.
Persists up to high $p_T$-trig.

# Path length effect on ridge correlations




$3< p_T^{trig} < 4$ GeV/c, $p_T^{asso}$ : 1.0- 1.5 GeV/c

Jet: Slight to no increases with $\varphi_S$.

Au+Au ~ d+Au

Ridge: Decreases with $\varphi_S$

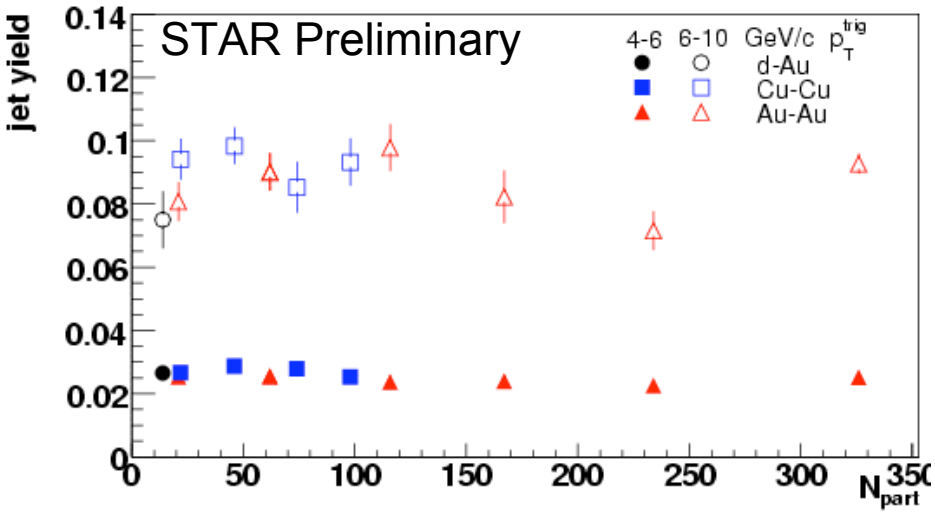
Little to no ridge at larger $\varphi_S$

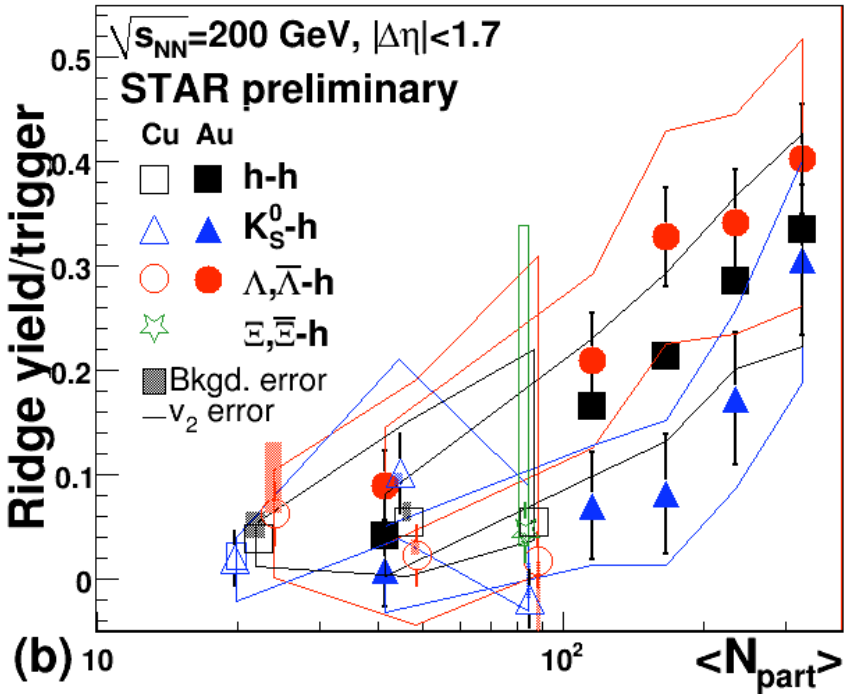
Strong jet-medium interaction when in reaction plane

Minimal jet-medium interaction when perp. to reaction plane

# Ridge : system size, centrality

$p_{T\ assoc}$ >3 GeV



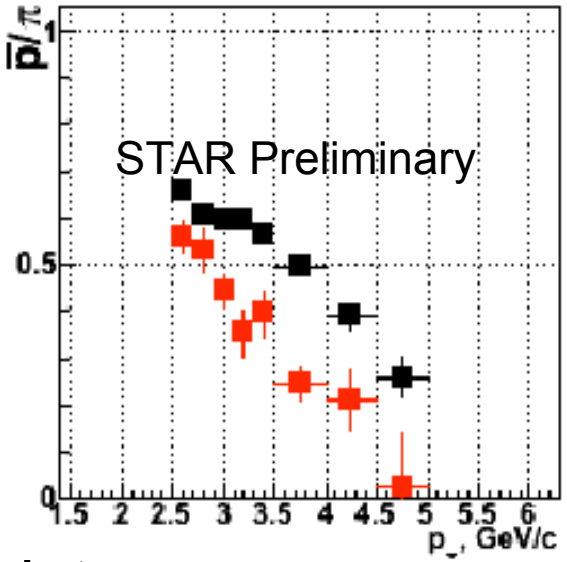




- ✓Near-side jet yield independent of colliding system, $N_{part}$ and trigger particle type
- ✓Ridge yield increases with $N_{part}$

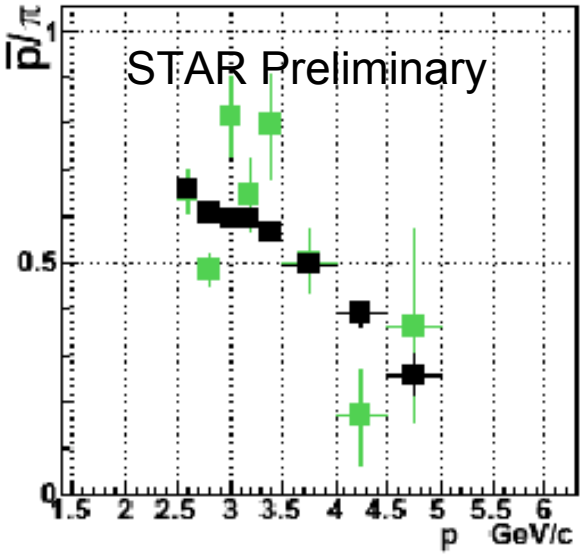
O. Catu and C. Nattrass QM08

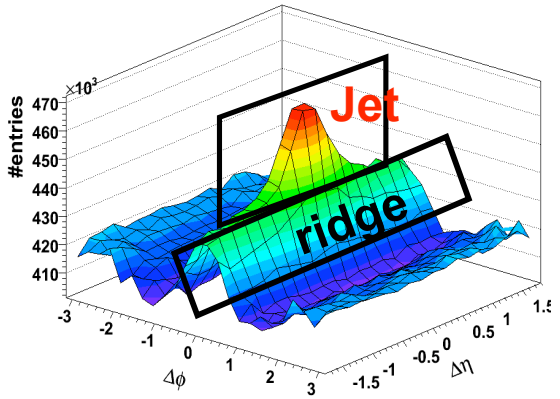
# Particle Ratios : Jet & Ridge

**Jet Cone vs. Bulk**




**Ridge vs. Bulk**




Jet:

$\Lambda/K^0_s$ ~ 0.5 < inclusive

(anti)p/$\pi$ < inclusive

- ✓ Ratios in cone smaller than inclusive
- ✓ Ratios in ridge similar to inclusive

Ridge:

$\Lambda/K^0_s$ ~ 1 ~ inclusive

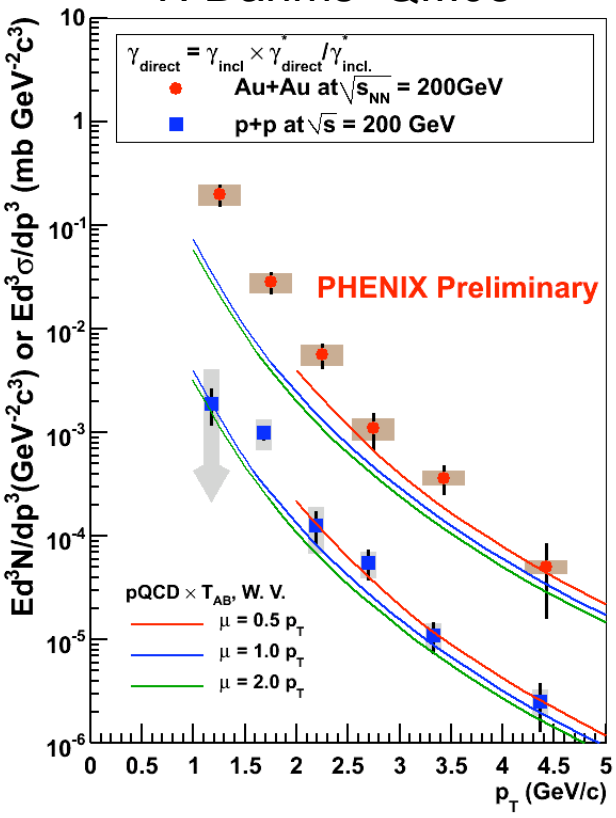
(anti)p/$\pi$ ~ inclusive

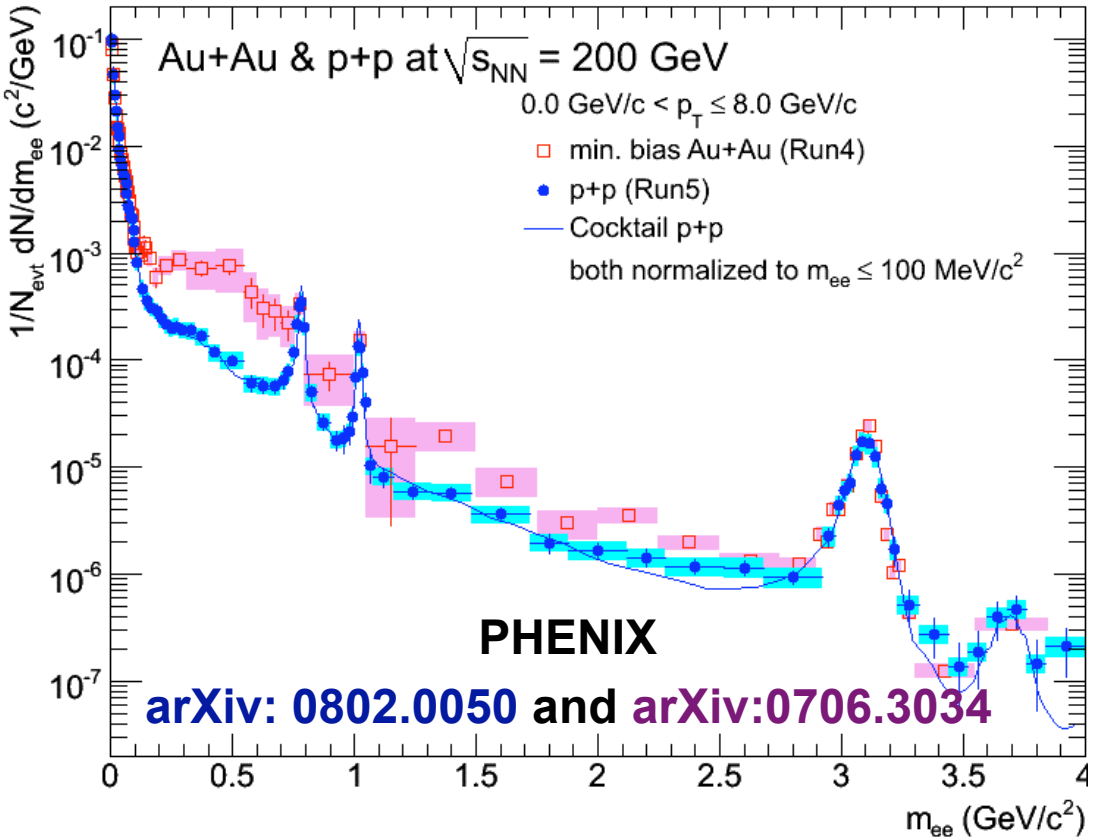
Properties of the ridge similar to the bulk and different of the jet

, J.Zuo, C.Suarez QM08

# Direct γ and low mass dilepton for p+p, Au+Au

T. Dahms QM08




- Low mass dielectron : Enhancement at low mass in central AuAu, especially at low pt
- Direct photon :significant low $p_T$ excess above p+p expectations
  - **Excess from thermal photon emission -> Initial T**

# Summary and Outlook

- Energy loss
  - Higher statistics allows to gain in sensitivity to determine initial density of the medium
  - Color factor effect not observed at high pt region, are we sensitive ? We need calculations !
  - Heavy quark energy loss still unsolved but progress with B/(B+D) ratio, next step measurement with vertex detector
  - Correlation : properties of the ridge similar to the bulk and different of the jet

# Summary and outlook

- What are the sources of the dilepton excess at low mass ? Thermal photon ?
  - Thermal photon can reveal about thermodynamic info
  - Interpretation soon ? T fit ?
- First step towards quantitative comparison between theory and experiment that will characterize the properties of the medium
  - Higher statistics
  - new analysis approaches
- Theory analysis should go hand in hand with the experimental effort to yield quantitative results